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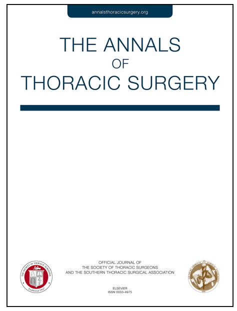

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Vertical Right Axillary Mini-Thoracotomy for Correction of Ventricular Septal Defects and Complete Atrioventricular Septal Defects

Running Head: Mini thoracotomy for VSD and CAVSD

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Key Words: Vertical right axillary mini-thoracotomy**,** ventricular septal defect, complete atrioventricular septal defects

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Abstract

Background. Vertical-right-axillary-mini-thoracotomy (VRAMT) is the standard approach for correction of atrial septal defect (ASD) and partial atrioventricular septal defects (PAVSD) at our institution. This observational single-centre study compares our initial results with the VRAMT approach for the repair of ventricular septal defects (VSD) and complete atrioventricular septal defects (CAVSD) in infants and children to an approach using standard median sternotomy (MS).

Methods. Perioperative course of patients undergoing VSD and CAVSD correction through either a VRAMT or a MS were analysed retrospectively. The surgical technique for the VRAMT involved a 4-5 cm vertical incision in the right axillary fold.

Results. Of 84 patients, 25 patients (VSD, n=15; CAVSD, n=10) underwent correction through a VRAMT approach, whereas 59 patients (VSD, n=35; CAVSD, n=24) had repair through MS. VSD and CAVSD-groups were comparable with respect to age and weight. No significant differences were observed for aortic cross-clamp duration, intensive care unit stay, hospital stay and echocardiographic follow-up. There was no need for any conversion from VRAMT to MS in any case. No wound infection nor thoracic deformities were observed in both groups.

Conclusions. VRAMT can be considered as a safe and effective approach for the repair of VSD and CAVSD in selected patient groups, and the outcome data appears comparable to those of median sternotomy.

Evolving surgical techniques and medical care have led to a significant decrease of the mortality and complication rate following congenital heart surgery during the past decades. A complete surgical repair allows both a normal life expectancy and excellent quality of life in the majority of children. At the same time, there is a quest for less invasive and aesthetically superior surgical access [1-3]. Median sternotomy (MS) has been the standard surgical approach for heart surgery, providing optimal exposure of all cardiac structures and allowing easy accessibility for central arterial and venous cannulation and installation of cardio-pulmonary-bypass (CPB). However, median sternotomy is invasive and results in a scar that is well visible on the chest of growing children, which can be potentially stigmatising and trigger long-lasting psychological distress [4-6].

Consequently, several alternative surgical approaches have been proposed like right anterolateral thoracotomy [7,8], posterolateral thoracotomy [9,10], and partial sternotomy [3,11]. They have however been concluded as suboptimal, sometimes because of visibility of the scar, sometimes because of long term consequences like thorax deformity or, especially such as the anterolateral-thoracotomy when performed in pre-pubescent females, impairment of breast development [12,13].

The axillar region represents an interesting surgical access to the thoracic cavity due to particular anatomical properties: The skin is flexible, muscles are relatively rare and can therefore be spared, it is far away from breast tissue in girls, and the resulting scar is hidden under the resting arm [6]. As other studies have already examined, the right axillary access has proven sufficiently exposure of the right atrium and right heart structures, as needed for instance for ASD, VSD and CAVSD. [4]. Furthermore, an eventual scar in the right axilla has shown to be fairly unsuspicious for heart disease, since the anatomical correlation to the heart in the right hemi-thorax is not given [6].

Several groups have already reported their experience with this approach for the correction of atrial-septal-defect (ASD), ventricular-septal-defect (VSD), and partial-atrioventricular-septal-defects (PAVSD) [6,14-18]. Correction of complete-atrioventricular-septal-defects (CAVSD) through a vertical-right-axillary-mini-thoracotomy (VRAMT) has not yet been described before.

The objective of this study is to analyse outcomes and surgical results of VRAMT for correction of VSD and CAVSD in comparison to repair through a MS.

Patients and Methods

Patient selection and data collection

An observational retrospective single-centre study was conducted using perioperative clinical patient data retrieved from clinical records, surgery and follow-up reports. The study was approved by the Cantonal-Ethics-Committee (approval no. 2016-01484). Patients who underwent corrective heart surgery by VRAMT for either a perimembranous VSD or a CAVSD (Rastelli type A), starting from January 2012 until August 2016 were included and compared to patients who underwent correction via MS. All surgical procedures either VRAMT or MS for the correction of VSD or CAVSD were performed by the same surgeon (AK). To ensure comparability between study groups, patients with a body weight >10 kg were excluded. An observational design was used conforming to the STROBE statement [19]. All data was gathered in a standardized database using the Research-Electronic-Data-Capture (REDCap) system. Patient characteristics, procedural data and outcomes are shown in Tables 1-4.

Patient selection for VRAMT

Since several years, VRAMT has been the standard approach for repair of secundum ASD, sinus venosus defect, partial-anomalous-pulmonary-venous-return, partial atrioventricular septal defects, permanent pacemaker and ICD-implantation in paediatric patients at our institution. Given the growing experience with this cosmetically appealing and less invasive approach, and its comparable results, our group extended its use, since 2012, to perimembranous VSD repair. Since 2014 we also used the VRAMT approach for elective correction of CAVSD with a Rastelli classification type A [20].

Statistical analysis

Variables were presented as numbers with % or as median with interquartile ranges. Differences were investigated using Fisher's exact test for four filed tables, χ^2 test for tables with more than four fields and Kruskal-Wallis test for continuous variables and were presented with 95% confidence interval (CI). All p values and confidence intervals were two sided. All calculations were performed using Stata 12 (College Station, Texas).

Follow up

The follow-up included ambulatory visits with clinical examination and echocardiography by senior paediatric cardiologists at one, three and six months postoperatively, and yearly thereafter. All follow-up data until 31st of August 2017 were included in the analyses. Follow-up variables are presented as numbers with percent or as mean ± standard deviation (SD). For the purpose of this study all echocardiographic data at discharge and the most recent follow-up are included.

Definition of major adverse cardiac and cerebrovascular events

Major adverse cardiac and cerebrovascular events (MACCE) was defined as one of these events: sudden cardiac death, fatal or non-fatal myocardial-infarction (MI), arrhythmias needing intervention with permanent pacemaker, stroke, or renal failure requiring prolonged dialysis. MI criteria for this study were defined according to the *2012 Third Universal Definition of Myocardial Infarction by the European Society of Cardiology Guidelines*. elevation of cardiac biomarker values >10 x 99th percentile URL in patients with normal baseline troponin values. In addition, either (i) new pathological Q waves or new LBBB, or (ii) angiographic documented new native coronary artery occlusion, or (iii) imaging evidence of new loss of viable myocardium or new regional wall motion abnormality [21].

Surgical technique

Patients received general anaesthesia after induction with sevoflurane, sufentanil and rocuronium. For tracheal intubation, a single-lumen paediatric endotracheal tube was used. Intraoperative monitoring consisted of American-Society-of-Anaesthesiologists standard monitoring, invasive arterial blood pressure via a left-sided radial artery or left-sided femoral artery catheter, central-venous-pressure via a jugular venous catheter, nasopharyngeal temperature, urine output, transesophageal-echocardiography (TEE) and cerebral-near-infrared-spectroscopy (NIRS). Patients undergoing correction of VSD and CAVSD through a VRAMT were placed in a left decubitus position (Figure 1). Prior to positioning, the anterior, posterior axillary line and 4th intercostal space was outlined in supine position with arms in adduction. Following lateral positioning of the child the arm was elevated to expose the axillary region.

A vertical incision of 4-5 cm parallel to the right anterior axillary fold was performed overlying the 4th or 5th-intercostal-space. The subcutaneous tissue was generously mobilized. the serratus anterior muscle overlying the 4th-intercostal-space was identified and the lateral border of the pectoral muscle slightly mobilized. Care was taken to avoid injury to the long thoracic nerve and artery lying posteriorly on the serratus anterior muscle. Thoracotomy was performed at the superior margin of the 5th-rib in the 4th intercostal space. A retractor by *Fehling Surgical Instruments* (V-CUT Titanium MSX-1 for 3-7 kg Bodyweight or MSX-2 for 7-15kg Bodyweight) was used for VRAMT. The pericardium was opened 1- 2 cm anterior to the phrenic nerve (Figure 2 A.). Stay sutures were placed along both the margins of the pericardium and fixed to the surrounding drapes to retain the lungs.

CPB was established following cannulation of the ascending aorta and both vena cava. The inferior-vena-cava was either cannulated directly or in patients > 5kg a percutaneous-venous-cannula (BIO-MEDICUS, Medtronic, Pediatric-Venous-Cannulae) was inserted in the Seldinger-technique into the femoral vein and a LV-vent (Figure 2.B). CPB was conducted in mild-hypothermia, the aorta was cross-clamped directly and antegrade-cardioplegia was administered by using a low-dose (1.5 ml/kg), single-shot crystalloid solution (Cardioplexol™) [22]. The surgical repair of VSD and CAVSD through VRAMT was performed using standard technique and is shown in Figure 3. Deairing was performed via the LV-vent and the aortic root cardioplegia needle and removed after successful de-airing and echocardiographic confirmation of good left-ventricular function. During rewarming epicardial temporary-pacing-electrodes were placed to the right atrium and ventricle. Following decannulation and haemostasis the pericardium was closed except a distal opening of about 1-2 cm for drainage of pericardial fluid into the right pleura. A subpleural-paravertebral-catheter was placed covering two segments each cranial and caudal to the VRAMT interspace for postoperative pain management at a period of 72 hours, using a continuous infusion of bupivacaine 0.125% with adrenaline 5 mcg/ml. Two chest drains were inserted, and the chest was closed with absorbable suture material (Figure 4 A.).

Results

Perioperative Data

VSD patients

There were 50 patients included in the VSD group, n= 35 operated through median sternotomy (MS), and n= 15 patients through vertical right axillary mini-thoracotomy (VRAMT). Median age was 4.1 (3.5 - 5.7) months in the MS-VSD group and 4.3 (3.3 - 6.3) months in the VRAMT-VSD group (p= 0.841).

While 31% of patients were female in the MS-VSD group, the VRAMT-VSD group held a majority, 60%, of female patients. Patients were comparable regarding bodyweight (p= 0.525) and height (p= 0.688). Baseline data and additional diagnosis of VSD patients are shown in Table 1.

CAVSD patients

From a total of 34 patients with a CAVSD Rastelli type A, 24 were operated through MS and 10 patients through VRAMT. The median-age was 3.7 (3.1 - 7.8) months in the MS-group and 6.1 (4.5 - 10.5) months in the VRAMT-group. CAVSD patients were comparable for bodyweight (p= 0.174) and height (p= 0.219). Non-cardiac diagnosis included Trisomy 21 for 17 patients in the MS-group and 4 patients in the VRAMT-group. Table 2 shows the preoperative demographics of CAVSD patients.

Intra- and postoperative Assessment

None of the patients with VRAMT had to be converted to another surgical access. There were two postoperative deaths, one in the MS-VSD-group (Trisomy 18 with severe co-morbidities) and one in the MS-CAVSD-group (pulmonary hypertension crisis and resuscitation).

VSD patients

The intra- and postoperative data of VSD patients is listed in table 3. The median operating duration (p= 0.597) and aortic-cross-clamp-times (p= 0.182) were comparable between the groups. Cardiopulmonary bypass time was longer in the VRAMT groups (p= 0.015). The median ventilation-time resulted in 43 (22 - 82) hours for patients in the MS-group and 24 (17 - 47) hours in the VRAMT-group (p= 0.043).

CAVSD patients

The operating times for the VRAMT were significantly shorter (p= 0.003), whereas central CPB-time (p= 0.597) and aortic-cross-clamp-time (p= 0.241) of the patients in the MS and VRAMT-group were comparable. Postoperative rhythms in the MS-group included one persistent AV-Block III° with the indication for a permanent pacemaker. Table 4 shows the intra- and postoperative data of CAVSD patients.

Echocardiographic Follow-up

VSD patients

For VSD patients the mean follow-up was complete with a time of 8.1 months (±6.9) in the VRAMT-group and 52.3 months (±25.7) in the MS group. No significant residual defects were found in patients of both groups. No patient required a reoperation. At last follow-up, there were four patients with trivial residual VSDs, two in the MS-VSD-group, and two in the VRAMT-VSD-group respectively. In clinical examination, no wound complications or thoracic deformity has been found during the follow-up.

CAVSD patients

Mean follow-up time in the CAVSD-group was complete with a mean follow-up time of 8.6 months (± 10.3) in the VRAMT-group and 52.9 months (± 28.9) in the MS group. No patient required a reoperation during the follow-up period. At last follow-up, trivial residual VSDs were found in two patients from the MS-CAVSD-group.

Left AV-valve insufficiency was found in 17 patients (77%) in the MS-CAVSD-group (trivial n=15, mild to moderate n=2) vs. seven patients (70%) in the VRAMT-CAVSD-group (Trivial n= 5, mild to moderate n=2), respectively. In the MS-CAVSD-group 15 patients (68%) presented with trivial and one patient (5%) with mild to moderate right AV-valve insufficiency, while in the VRAMT-CAVSD-group six patients (60%) with trivial right AV-valve insufficiency. In clinical examination, no wound complications or thoracic deformity has been found during the follow-up.

Comment

The use of less invasive lateral thoracotomy in paediatric patients for the correction of congenital heart defects has been reported as feasible and safe in various publications [4,5,18,23,24]. The vertical right axillary mini-thoracotomy aims to provide superior cosmetic results without compromising the surgical outcome when employed for congenital heart defects, such as atrial septal defects (ASD), ventricular septal defect (VSD), and partial atrio-ventricular septal defects (PAVSD).

In our institution, the surgical correction of perimembranous ventricular septal defects through a right-axillary-mini-thoracotomy was started in 2012. Due to the growing experience and surgical results, and the high satisfaction of the children and their parents, as well as cardiologists, we extended this approach to the correction of “simple” CAVSD with a Rastelli type A. To our knowledge, there are no reports on the application of a VRAMT approach for the correction of CAVSD.

As far as aortic-cross-clamp-times, cardiopulmonary-bypass-time and operation-time are concerned, VRAMT procedures are comparable to standard MS surgery, indicating an adequate exposure and access to the anatomical structures. Furthermore, VRAMT procedures can be performed using standard instruments for access and the correction itself. These findings confirm previously reported advantages and results by other groups [4,18,23-25].

As an advantage of our approach patients weighing < 5kg were operated with central arterial and venous cannulation avoiding potential peripheral vascular complications. In patients weighing > 5 kg peripheral percutaneous-femoral-venous-cannulation was performed. No vascular complications were encountered. The use of femoral artery cannulation for CPB has led to vascular complications in other studies and should therefore be performed only with limited indication and meticulous technique [4,25].

The echocardiographic follow-up revealed a moderate AV-valve insufficiency in two patients for the MS-CAVSD-group (8%) and also in two patients for the VRAMT-CAVSD-group (20%). Furthermore, no wound complications or development of thorax deformities were observed. Long-term follow-up revealed comparable surgical results for VRAMT in comparison to MS for VSD patients. There was no need for re-operations in the current follow-up period for VSD and CAVSD patients. The long term outcome after primary repair of CAVSD remains strongly influenced by the function of the left atrioventricular valve, including in particular the risk for reoperation [26]. Regarding reinterventions after VRAMT-CAVSD repair, our group would aim towards a re-thoracotomy in these patients. However, we have to admit, that the experience is limited to only two cases necessitating reoperation due to endocarditis after PAVSD repair and ASD repair. Both patients had an uneventful perioperative course and good surgical results.

In the current presented study collective there were two deaths in the MS-groups, one in the MS-VSD-group and one in the MS-CAVSD-group. The patient in the MS-VSD suffered from Trisomy 18 and severe neurological and respiratory insufficiency. Following assessment of the situation of the patient, an interdisciplinary team advised against corrective cardiac surgery, nevertheless the surgical intervention was the explicit wish of the patient's parents.

The intraoperative course was uneventful, however the patient developed progressive global hemodynamic and respiratory insufficiency starting at postop day 12. Four days later the interdisciplinary team together with the parents decided for limited palliative therapy.

The patient in the MS-CAVSD-group was diagnosed with Trisomy 21. Surgery was performed on an elective schedule with uneventful intraoperative course. During the first postoperative day, the patient was resuscitated because of a severe pulmonary hypertension crisis. ECMO implantation was performed. Unfortunately, the patient died on the 5^{th} postoperative day due to neurological complications and multi-organ failure. Overall the rate of MACE revealed no significant difference between the MS and VRAMT-groups.

In conclusion, this study confirms previous reports which described VRAMT as a feasible, efficient and safe approach for surgical repair of perimembranous VSD. Cardiopulmonary bypass can be performed without peripheral arterial cannulation. Furthermore, this approach can be applied to the correction of CAVSD with Rastelli type A. Considering the beneficial aesthetic factor of this less invasive approach and at the comparable surgical results in the long-term, VRAMT can be considered as an equal surgical approach for a broader range of congenital heart defects.

Study limitations

We acknowledge some limitations of our study. It was a retrospective observational analysis and therefore cause and effect are hard to establish.

List of Abbreviations

ASD - atrial septal defect

BMI - body mass index

CAVSD - complete atrioventricular septal defects

CD – chest drains

CI - confidence interval

CPB - cardio-pulmonary-bypass

CL - cardioplegia line

ICD - implantable cardioverter defibrillator

LBBB – left bundle branch block

MACCE - major adverse cardiac and cerebrovascular events

MI - myocardial infarction

PAVSD - partial atrioventricular septal defects

PE - pacing electrodes

PFO - persistent foramen ovale

PLSVC - persistent left superior vena cava,

MS - median sternotomy

NIRS - cerebral-near-infrared-spectroscopy

REDCap - research electronic data capture

SD - standard deviation

SVC - superior vena cava

TEE - transoesophageal-echocardiography

URL – upper reference limit

VRAMT - vertical-right-axillary-mini-thoracotomy

VSD - ventricular septal defects

Figure Legends

Figure 1. Placement of patients in a left decubitus position. The marked anterior axillary line and the 4th intercostal space serve as a guiding for the axillary incision.

Figure 2. (A) Vertical skin incision over the region of the 4th – 5th ICS with a length of 3 - 5 cm. Mobilisation of subcutaneous tissue and sparing of muscles. Visualization of the right atrium (arrow) and superior vena cava (SVC). (B) Direct access cannulation with aortic cannulation (Ao), venous cannulation of the superior vena cava (SVC) and cardioplegia line (CL). The inferior vena cava was cannulated using percutaneous technique.

Figure 3. (A) Surgical field after atriotomy for the correction of a perimembranous ventricular septal defect (VSD). (B) Closure of VSD with a xeno-pericardial patch (arrow).

Figure 4. (A) Initial postoperative access site after closed vertical skin incision. Chest drains (CD) in the right pleural cavity and placement of atrial/ventricular pacing electrodes (PE). (B) Long-term cosmetic result after VSD closure through VRAMT.

Table 1. Preoperative Data of VSD Patients.

Demographics VSD-cohort	**MS N = 35**	**VRAMT N = 15**	**Difference and 95% confidence interval**	**p Value**
Age [months]	4.1 (3.5; 5.7)	4.3 (3.3; 6.3)	-0.2 (-2.5; 2.2)	0.841
Premature Birth (SSW< 37)	6 (17%)	2 (13%)	4% (-19%; 27%)	1.000
Gender (Female)	11 (31%)	9 (60%)	-29% (-58%; 1%)	0.114
Weight (kilograms)	5.0 (4.4; 6.2)	5.7 (4.3; 6.8)	-0.3 (-1.2; 0.5)	0.525
Height (cm)	61.0 (58.0; 65.0)	60.0 (58.0; 69.0)	-1.1 (-5.2; 3.0)	0.688
BMI	13.7 (12.8; 14.3)	13.5 (12.2; 15.8)	-0.4 (-1.4; 0.7)	0.604
Body Surface Area [m^2]	0.3 (0.3; 0.3)	0.3 (0.3; 0.3)	-0.0 (-0.0; 0.0)	0.539
Additional cardiac diagnosis				
ASD Type II	17 (49%)	9 (60%)	-11% (-43%; 20%)	0.545
PLSVC	2 (6%)	1 (7%)	-1% (-16%; 14%)	1.000
PFO	7 (20%)	0 (0%)	20% (-1%; 41%)	0.087
Non-cardiac diagnosis				
Genetic	12 (34%)	2 (13%)	21% (-7%; 49%)	0.179
Trisomy 18	1 (3%)	0 (0%)	3% (-6%; 12%)	1.000
Trisomy 21	9 (26%)	2 (13%)	12% (-14%; 38%)	0.468
Di George-Syndrome (22q11-Syndrom)	1 (3%)	0 (0%)	3% (-6%; 12%)	1.000
Neurology	2 (6%)	0 (0%)	6% (-7%; 18%)	0.519
Metabolic	2 (6%)	1 (4%)	-1% (-16%; 14%)	1.000
Urogenital	1 (3%)	0 (0%)	3% (-6%; 12%)	1.000
Visceral	1 (3%)	0 (0%)	3% (-6%; 12%)	1.000

BMI: body mass index, ASD: atrial septal defect, PLSVC: persistent left superior vena cava, PFO: persistent foramen ovale. Variables are presented as numbers with % or as median with interquartile ranges.

Table 2. Preoperative Data of CAVSD Patients.

Demographics CAVSD-cohort	MS N = 24	VRAMT N = 10	Difference and 95% confidence interval	p Value
Demographics				
Age [months]	3.7 (3.1; 7.8)	6.1 (4.5; 10.5)	5.7 (-16.8; 28.1)	0.121
Premature Birth	5 (21%)	0 (0%)	21% (-6%; 48%)	0.291
Gender (Female)	13 (54%)	5 (50%)	4% (-35%; 43%)	1.000
Weight (kilograms)	4.9 (4.4; 6.9)	5.8 (4.6; 8.0)	0.6 (-3.6; 4.7)	0.174
Height (cm)	59.0 (56.0; 65.5)	67.0 (57.8; 68.5)	0.8 (-13.4; 15.0)	0.219
BMI	14.2 (13.2; 15.4)	14.4 (13.3; 17.1)	-0.6 (-2.2; 0.9)	0.484
Body Surface Area [m^2]	0.3 (0.3; 0.3)	0.3 (0.3; 0.4)	0.0 (-0.1; 0.2)	0.212
Additional cardiac diagnosis				
PLSVC	1 (4%)	0 (0%)	4% (-9%; 17%)	1.000
PFO	2 (8%)	0 (0%)	8% (-10%; 27%)	1.000
Non-cardiac diagnosis				
Trisomy 21	17 (71%)	4 (40%)	31% (-6%; 68%)	0.130
Neurology	2 (8%)	1 (10%)	-2% (-24%; 21%)	1.000
Metabolic	1 (4%)	2 (20%)	-16% (-37%; 6%)	0.201
Urogenital	1 (4%)	0 (0%)	4% (-9%; 17%)	1.000
Visceral	4 (17%)	0 (0%)	17% (-8%; 41%)	0.296

BMI: body mass index, PLSVC: persistent left superior vena cava, PFO: persistent foramen ovale. Variables are presented as numbers with % or as median with interquartile ranges.

Table 3. Intra- and postoperative Data of VSD Patients.

Intraoperative Data	MS N = 35	VRAMT N = 15	Difference and 95% confidence interval	p Value
OR-time [min]	155 (140; 180)	155 (130; 180)	3.0 (-17.4; 23.3)	0.597
CPB-time [min]	63 (56; 77)	77 (63; 90)	-17.5 (-28.2; -6.9)	**0.015**
Aortic-cross-clamp-time [min]	36 (29; 41)	41 (33; 51)	-5.0 (-10.8; 0.9)	0.182

Postoperative Data	MS N = 35	VRAMT N = 15	Difference and 95% confidence interval	p Value
Postoperative				
Fast-Track: Extubation in OR	0 (0%)	1 (7%)	-7% (-15%; 2%)	0.300
ICU Stay [h]	96.0 (72.0; 166.0)	72.0 (48.0; 164.0)	30.0 (-14.2; 74.3)	0.212
Ventilation [h]	43.0 (22.0; 82.0)	24.0 (17.0; 47.0)	30.3 (-0.8; 61.4)	**0.043**
Hospital Stay [in d]	10.0 (8.0; 13.0)	9.0 (8.0; 12.0)	7.4 (-10.4; 25.1)	0.727
Mortality				
Mortality	1 (3%)	0 (0%)	3% (-6%; 12%)	1.000

OR: operation room, ICU: intensive care unit, CPB: cardio-pulmonary-bypass. Variables are presented as numbers with % or as median with interquartile ranges

Table 4. Intra- and postoperative Data of CAVSD Patients.

Intraoperative Data	MS N = 24	VRAMT N = 10	Difference and 95% confidence interval	p Value
OR-time [min]	225 (195; 269)	189 (171; 198)	52.8 (20.0; 85.6)	**0.003**
CPB-time [min]	106 (84; 144)	106 (93; 119)	8.0 (-13.8; 29.8)	0.597
Aortic-cross-clamp-time [min]	68 (55; 78)	64.0 (48; 72)	8.6 (-2.7; 19.9)	0.241

Postoperative Data	MS N = 24	VRAMT N = 10	Difference and 95% confidence interval	p Value
ICU				
Fast-Track: Extubation in OR	1 (4%)	0 (0%)	4% (-9%; 17%)	1.000
ICU Stay [h]	151.5 (92.3; 229.8)	126.0 (112.5; 192.0)	48.3 (-74.9; 171.5)	0.431
Ventilation [h]	71.5 (31.0; 100.8)	32.5 (23.8; 54.0)	43.4 (-1.3; 88.1)	0.059
Hospital Stay [in d]	14.0 (8.0; 29.0)	12.5 (8.0; 20.0)	6.3 (-6.4; 18.9)	0.681
MACCE				
Renal failure	1 (4%)	0 (0%)	4% (-9%; 17%)	1.000
Stroke	1 (4%)	0 (0%)	4% (-9%; 17%)	1.000
Pacemaker Implantation	1 (4%)	0 (0%)	4% (-9%; 17%)	1.000
Mortality				
Mortality	1 (4%)	0 (0%)	4% (-9%; 17%)	1.000

OR: operation room, ICU: intensive care unit, CPB: cardio-pulmonary-bypass MACCE: major adverse cardiac and cerebrovascular events. Variables are presented as numbers with % or as median with interquartile ranges.

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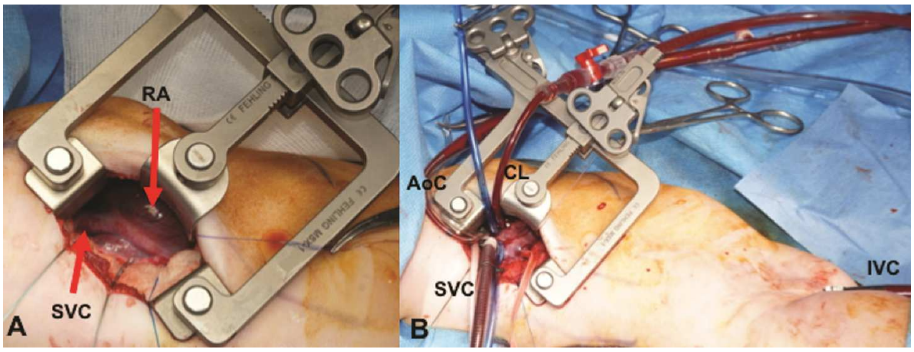
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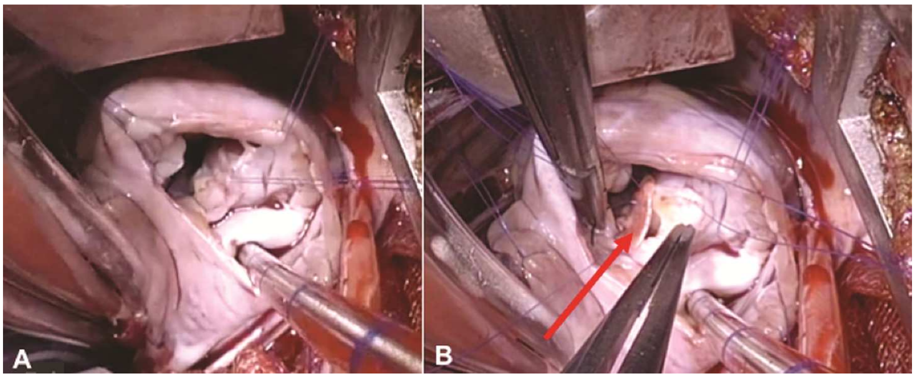
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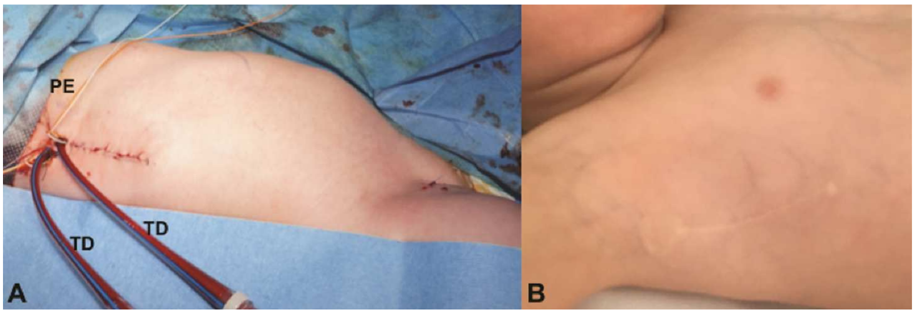
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